

**EFFECTS OF RESTRICTED (SO-CALLED ULCER) DIETS UPON
GASTRIC SECRETION AND MOTILITY.¹**

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MEDICAL literature offers several studies of the clinical end-results of medical treatment of gastric and duodenal ulcers. The chemism and physiology of the stomach after operation has also been studied. But practically no information can be obtained regarding the direct results upon the stomach of the various forms of medical treatment. Whether clinical improvement during an ulcer cure depends upon a change in the chemistry and motility of the digestive organ remained until recently a matter of speculation rather than a demonstrated fact. The most illuminating articles on this subject are those contributed by W. W. Hamburger,² of Chicago. He was able to demonstrate (by radiographic means) during intensive medical treatment the actual healing of ulcers, the disappearance of "niche" phenomena and the restoration of normal peristalsis and motility. While he refers from time to time to changes in the chemistry of the organ as a result of restricted diet, his attention is focussed mainly on the radiographic picture of the healing ulcers.

J. Friedenwald and Baetjer³ carefully observed radiographically the function of the stomach during medical treatment. Their observations led them to conclude that several weeks, even months, of protracted diet were necessary before the disappearance of signs of abnormal function, such as exaggerated peristalsis, delayed motility, irregularity of contour, etc. The studies of Friedenwald and Baetjer are the first attempt directly to observe the effect of medical treatment on healing ulcers.

It is upon the chemism and the motility of the stomach while undergoing medical treatment that I am attempting to contribute some facts. This paper is based on observations made upon 34 patients. The cases belong in one general group; they were either proved instances of gastric or duodenal ulcer or they were cases suspected of bearing ulcers. In 5 of the patients ulcer was demonstrated by operation at a later date; in 21 of the cases ulcer was the

¹ It is a great pleasure to acknowledge with sincere thanks the kind privileges extended by the attending physicians of the hospital in the course of this study.

² AM. JOUR. MED. SC., 1913, clv, 204.

³ Tr. Assn. Am. Phys., 1903, p. 9.

clinical diagnosis, based upon the history, physical findings, chemical data and radiographic evidence. In the remaining 8 subjects the final clinical opinion was that they were suffering from a gastric neurosis or a functional disturbance of the stomach.

The symptoms which these patients presented in common were periodic attacks of heartburn, pain after meals, acid eructations, occasional vomiting and loss of weight. Practically in all these cases hyperacidity was chemically demonstrable, hypersecretion was frequently present and delayed emptying of the digestive organ was a prominent factor.

Since intra-abdominal diagnosis at its very best is conceded to be inaccurate and open to error, it is better in this study to consider the effects of the diet upon the chemistry of a diseased stomach *per se* rather than upon the ulcer when and if present. In this study no light is thrown upon the pathological changes that an ulcer undergoes during medical treatment. Only the immediate effects of the dietary restriction are studied. The observations extended, as a rule, over from two to five weeks in each case; the remote effects of medical treatment are not considered.

PROCEDURE. The routine examination of these patients upon admission consisted of a careful history and physical examination, extraction of fasting gastric contents, Ewald test breakfast and other chemical tests, stool examinations for occult blood and finally a thorough radiographic examination. A fractional test-meal to establish the type of curve was also performed. After the collection of all data the patient was placed upon a restricted diet for a period of from two to four or more weeks. During the period of observation, fractional test-meals were taken every few days. The type of the acid curve, its maximum height, its duration, the presence of hypersecretion, the emptying time, etc., were carefully noted for any changes that could be interpreted as due to the form of treatment being instituted. Clinical notes were made from time to time so as to ascertain a possible parallel between improvement in subjective symptoms and a change for the better in the disturbed chemism of the organ. The fractional test-meal was chosen as the best laboratory method for the demonstration of the phases of gastric digestion. By this method, so intimately associated with the name of Rehfuess, the height and duration of the acid secretion can be computed and plotted, evidence of pathological hypersecretion becomes manifest and the emptying time of the organ accurately estimated for a given and constant test-meal (oatmeal gruel in this study).⁴

BASIC PRINCIPLES OF SO-CALLED ULCER DIETS. There are certain general characteristics which are common to all forms of so-called ulcer diet. These are:

⁴ Crohn and Reiss: AM. JOUR. MED. SC., 1917, cliv, 857.

1. Administration of highly nutritious foods in small quantities, frequently repeated.

2. Neutralization of the free acid of the digesting stomach.

This is accomplished by administering high proteid foods, mainly milk, with the addition of eggs and later of cereals. Antacid salts are commonly employed to assist the neutralizing action of the foods.

An improvement in the motility of the stomach is sought in cases in which emptying time is delayed. In the series studied, patients were subjected either to a Lenhartz diet carried out without modification or to a diet similar to the one advocated by Sippy.⁵ In the diet as we administered it, milk and cream in small doses (2 or 3 ounces) were given hourly during the day for the first three days; cereals were then added twice daily. At the end of a week two eggs a day were added and puréed vegetables were gradually introduced. All forms of meat were withheld until the third week. Antacids in small quantities were given between feedings; bismuth was a constant component of these powders. Occasionally gastric lavage for food stasis was employed, though this was fortunately rarely indicated.

Before proceeding to discuss the general effect of such a diet upon the gastric chemism, let us study the individual chemical reaction which results upon the introduction into the stomach of these various foods. As a control one should keep in mind the normal curve of secretion, while employing oatmeal gruel as a test-meal or the usual Ewald test breakfast. Chart I demonstrates the reaction of a patient with a normal curve to a test-meal consisting of 240 c.c. of milk. One notes immediately the fact that milk causes a high total acidity (up to 128 c.c. $\frac{N}{10}$ sodium hydrate per 100 c.c.); that the height of the acidity is maintained for three or four hours; that free acid is present in larger quantities than usually met with in cereal or bread test breakfasts, and that the stomach takes considerably longer to empty itself. The acid-binding qualities of milk are apparent in only the first half-hour; thereafter to the end of digestion free acid is liberally present.

Compare this with the exaggerated effects of a combination of milk and eggs (Chart II). The total acid curve mounts still higher, reaching a maximum of 146 per cent.; free acid becomes evident after one and a half hours and is present in strong concentration during the remainder of the digesting cycle. Emptying time is, as a result, prolonged, even allowing for the large amount of test-meal given. A free hypersecretion of concentrated acid persists after the disappearance of the last traces of food.

The behavior of a cupful (280 c.c.) of clear bouillon, as recommended in the von Leube diet, is similarly interesting (Chart III).

⁵ Jour. Am. Med. Assn., 1915, lxiv, 1625.

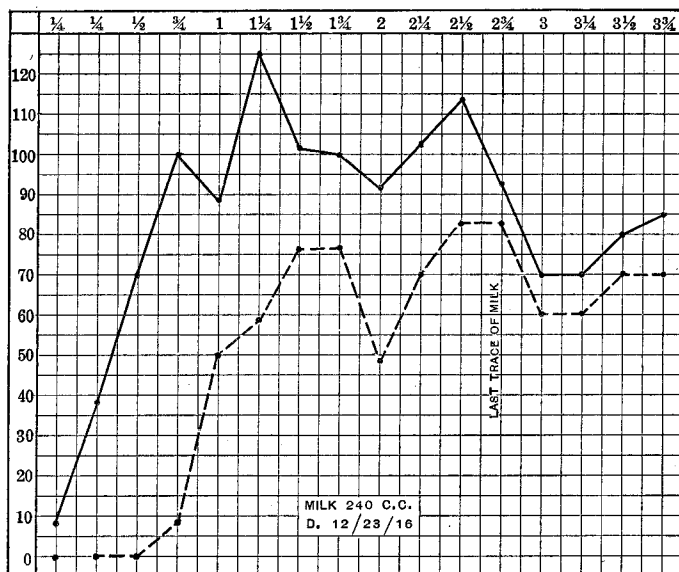


CHART I

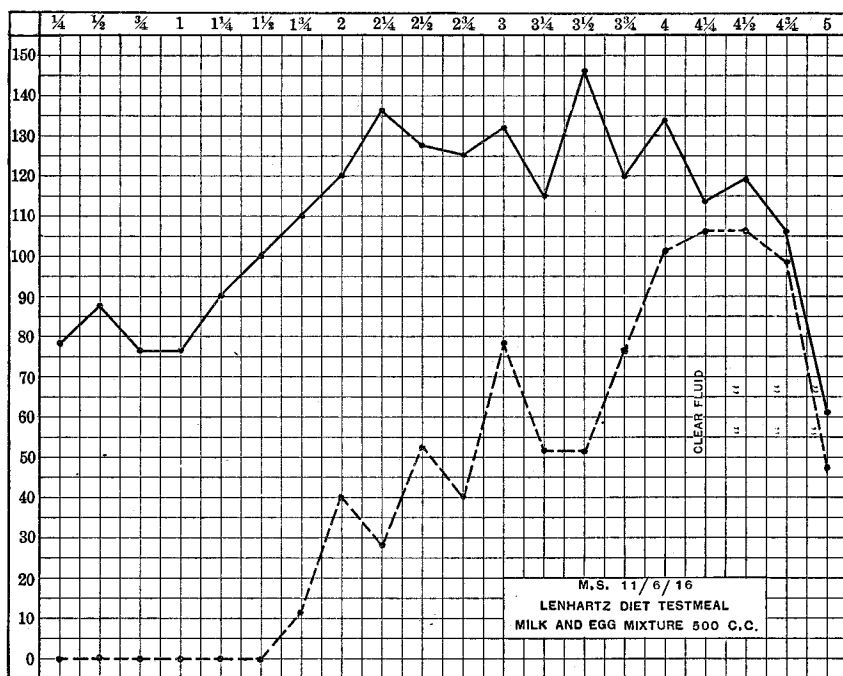


CHART II

No considerable binding of acid is at any time demonstrable. A high acidity, both free and total, quickly takes place and is maintained for two hours; thereafter the stomach is empty.

The conclusions to be drawn are: Milk is a strong acid stimulant and is only slowly emptied through the pylorus. The combination of milk and egg is a powerful stimulant to gastric secretion, causing a hyperacidity and hypersecretion, with prolongation of the emptying time. Bouillon fails to bind acid and is a mild digestive stimulant.

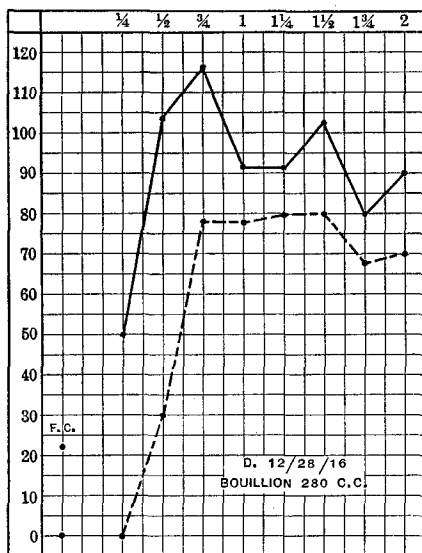


CHART III

The justification for the frequent repetition of food in small quantities is seen in Chart IV. Here we observe the effect upon the secreting organ of three ounces of milk repeated hourly. While the total acidity remains moderately high (average 80 per cent.) very little free acid is allowed to accumulate. As the free acid curve tends to rise toward the conclusion of each fifteen-minute period it meets the new portion of milk imbibed and is immediately neutralized. Since peptolytic digestion occurs only in the presence of free acid, it is apparent that in so far as actual splitting of the compound proteid molecule is concerned this stomach is really inactive.

If to this hourly administration of milk we add an alternating small dose of antacid salts (bismuth and bicarbonate or magnesia and bicarbonate in 5-grain doses of each as advocated by Sippy⁵), we are enabled to note (Chart V) that free acid entirely disappears and

that even the total acidity is strongly controlled, averaging only 43 per cent. Peptolysis is absent throughout.

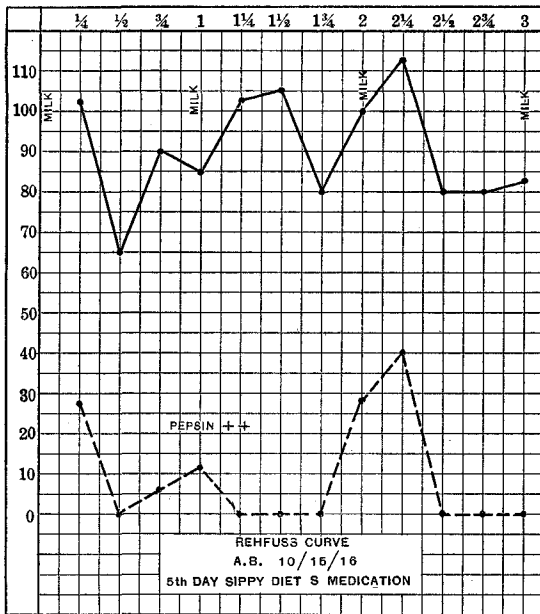


CHART IV

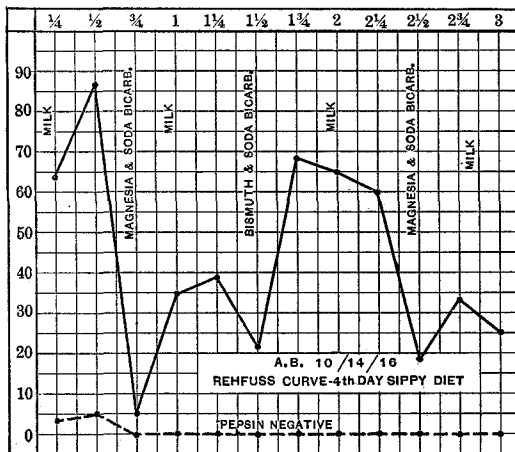


CHART V

If the reduction of total acidity and the complete neutralization or combining of free acid were the aims of this form of medical

treatment, then surely this plan of alternate milk and antacids fills all the requirements and offers the stomach the optimum conditions of anacidity for the cure of an ulcer.

However, of late much doubt has been thrown upon the hypothesis that ulcer of the stomach is due to the corrosive action of gastric juice. This theory really gained headway before the realization by the older clinicians of the fact that duodenal ulcer outnumbered in frequency gastric ulcers. The charted curve of acidity in the duodenum during digestion regularly fails to show the presence of any free acid, nor is the total acidity at any time high (Chart VI). The similarity between this chart and the preceding one is striking. Our approved methods of medical treatment aim to accomplish in

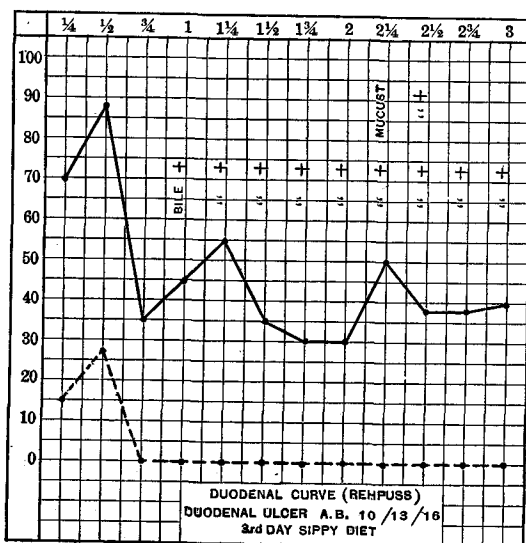


CHART VI

the stomach the very conditions of combined or neutralized acidity which are regularly and normally present in the so-called juxta-pyloric portion of the stomach or duodenum. Yet under these very highly desirable and optimum conditions of anacidity duodenal ulcers appear and grow.

A closer study of the entire subject tends only to raise more doubts as to the *modus operandi* of cure of ulcers by medical treatment. The causal relationship between the hydrochloric acid and ulcer has not been proved, nor are we able unquestionably to accept the hypothesis that the cure of ulcer depends on the neutralization of the free acid of the stomach.

However, clinically, the beneficial results of medical treatment cannot be denied or gainsaid; it behooves us therefore to proceed to

study the effects of days and weeks of the administration of such a regimen on the gastric secretion.

EFFECT OF MEDICAL TREATMENT ON GASTRIC ACIDITY. Of the 34 cases which constitute the basis of this study 11 cases had an isosecretory or hyposecretory curve and 24 a hypersecretory curve of acidity (Rehfuss⁶). Let us assume that a beneficial effect of the medical treatment would be the diminution of an excessive hyperchlorhydria and a return to a normal or hyposecretory type of curve. In the series observed, medical treatment succeeded in causing a definite lowering of the acid curve in 6 of the 11 cases, with iso- or hyposecretory curves; 5 of the 11 were unaffected or unchanged. Of the cases with marked hyperacidity, numbering 23 in all, only 7 showed a lowering of the acid curve; in the remaining 16 the curve remained high in spite of persistent and rigid dieting and rest in bed.

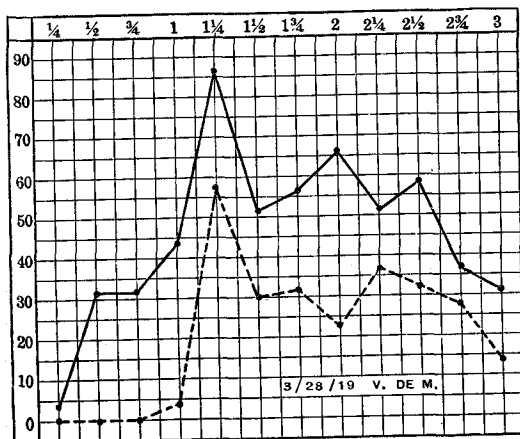


CHART VII

The lowering of the acid curve was often very marked, much more so in cases of hyperacidity than in those with normal or sub-acidity. Chart VII is the curve of a case of functional hyperacidity (operative findings negative) before the institution of treatment. Chart VIII the same case on the tenth day of a Lenhartz diet. The lowering of activity, diminution of hypersecretion and improvement in motility are marked.

Cases with normal curve of secretion, though suffering with symptoms of heartburn and belching, often show a similarly striking reduction of acidity to a subnormal or hyposecretory status.

Chart IX is the curve before treatment of a case of probable duodenal ulcer, with symptoms three years in duration; radiographically a persistent duodenal irregularity and stasis were visible.

⁶ Jour. Am. Med. Assn., 1914, lxiii, 11.

Chart X is the curve of the same patient on the fourth day of a Lenhartz treatment, Chart XI on the seventh day and Chart XII

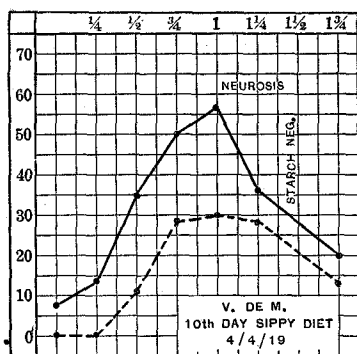


CHART VIII

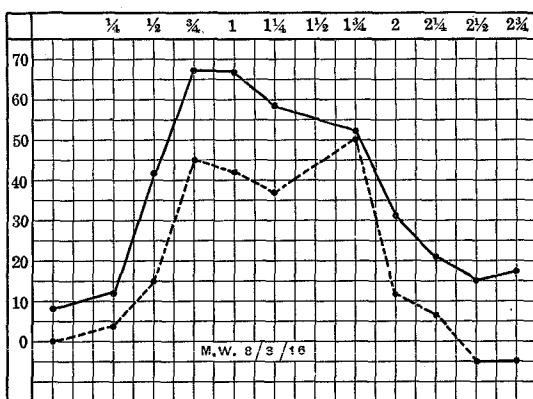


CHART IX

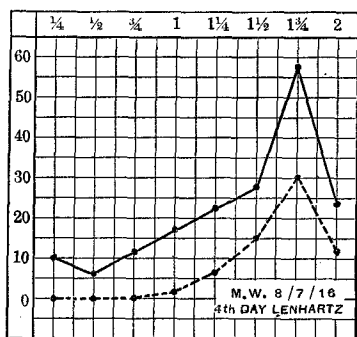


CHART X

on the twelfth day. The progressive lowering of acidity was accompanied by gradual improvement of subjective symptoms and disappearance of epigastric tenderness on pressure. This case, however, differs from the majority of the cases showing improvement, in that the reduction of acidity takes place as early as the fourth day of treatment. In most of the patients the chemical improvement was not demonstrable before the fifth to the seventh day. In more favorable cases the reduction of acidity began about the end of the first week of restricted diet and was maintained to the end of the period of observation. All of these cases but one were accompanied by marked relief from subjective clinical symptoms.

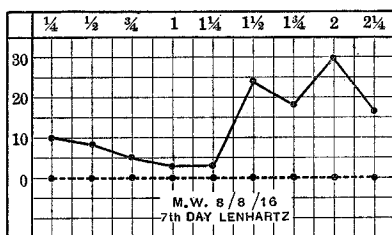


CHART XI

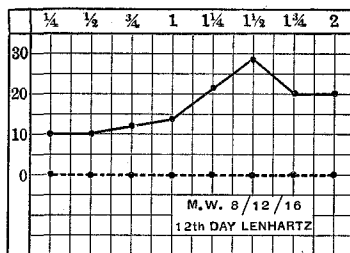


CHART XII

Of the 21 cases in which no reduction of acidity could be demonstrated little need be said; their curves resisted, many of them, even protracted restriction of diet, often meat-free for weeks. In spite of this more than half of these cases showed clinical improvement some of them markedly so.

The introduction of meat on the tenth day of the Lenhartz diet or the fourteenth day of the modified Sippy diet often converted a case which was tending toward diminished acidity into one with persistent hyperacidity. The following case is an illustration of this kind. The patient was one who had been suffering for seven months with symptoms of duodenal ulcer. A large indurated ulcer of the duodenum was in fact demonstrated at operation several months later. Chart XIII is the curve upon admission to the hospital (service of Dr. Manges).

Chart XIV the same on the fourth day of Lenhartz diet.

Chart XV the same on the sixth day of Lenhartz diet.

Chart XVI the same on the tenth day of Lenhartz diet, scraped beef having been given the patient for the first time on the previous day. The marked increase in acidity is noteworthy.

Chart XVII the same patient on the twelfth day of Lenhartz diet, meat having been removed from his diet. A slight improvement is noted.

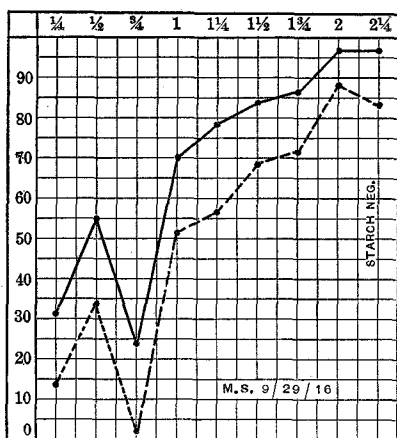


CHART XIII

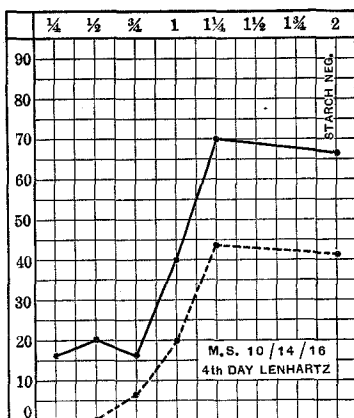


CHART XIV

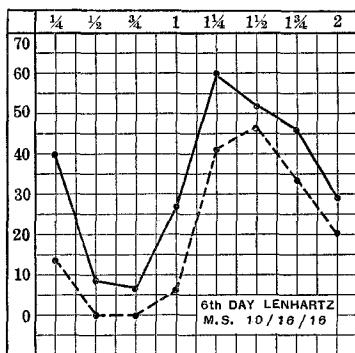


CHART XV

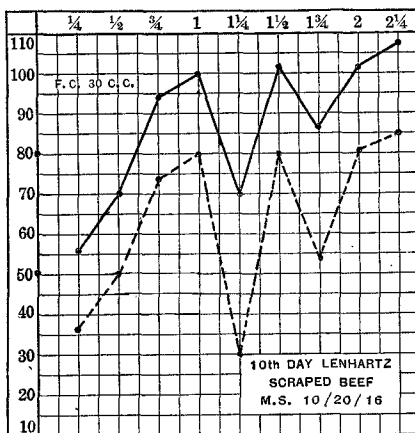


CHART XVI

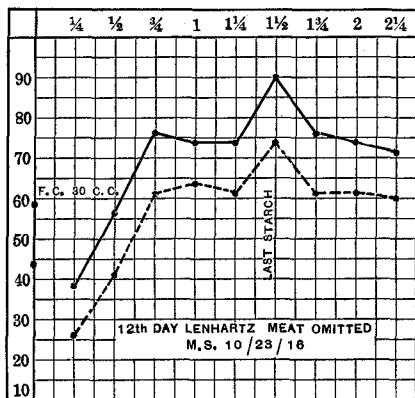


CHART XVII

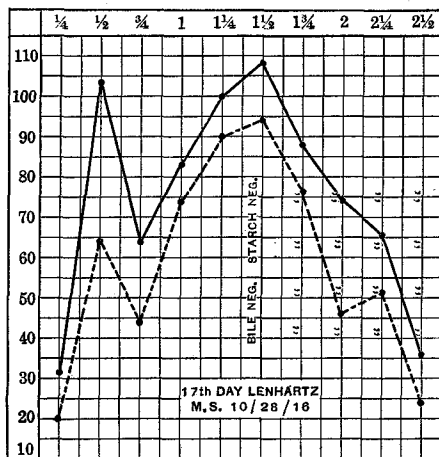


CHART XVIII

Chart XVIII is the curve on the seventeenth day of diet, still meat-free. Note the persistence of hyperacidity.

Repeated fractional tests of this patient were made up to the twenty-eighth day of the diet. (See Charts XIX and XX.) The hyperacidity hereafter failed to be reduced. The patient was discharged from the hospital free of subjective symptoms. Within a few weeks he returned with recurrence of his symptoms and was subsequently referred for surgical interference.

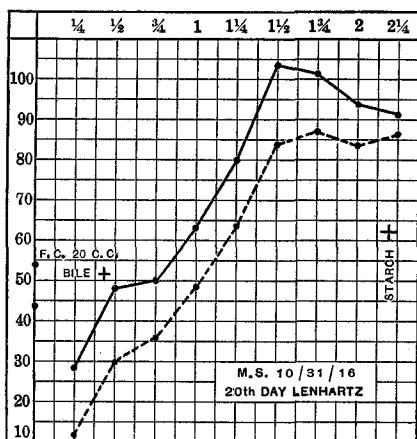


CHART XIX

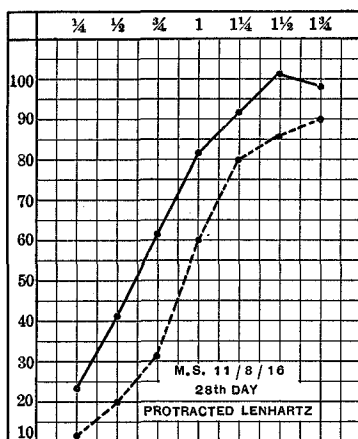


CHART XX

A vital question must occur to one's mind at this point. Is the reduction of hyperacidity which takes place during medical dietary treatment paralleled by clinical improvement, and conversely is a resistant hyperacid curve accompanied by persistent gastric symptoms?

Taking the cases as a whole 13 were chemically improved, 21 were not, a net chemical improvement of only 38.3 per cent. Yet clinically 25 of the 34 cases were discharged from the hospital free of symptoms, a percentage of 73.5 per cent., not quite as high as those presented by Lenhartz or von Leube, but still high. Of the 13 favorable cases in which the acid curve was reduced and the hyperacidity obliterated, 12 left the hospital symptom-free.

On the other hand, of the 21 cases with a persistent high acid curve in spite of treatment, 13, or 62 per cent., were markedly clinically improved. The remaining 38 per cent. (8 cases) left the hospital with the same curve as on admission, and clinically unimproved by their treatment.

A certain parallelism between chemical and clinical results is obvious.

TABLE I.

Acid curve, reduced, 13 (38 per cent.).
 Clinically improved, 12 (92 per cent.).
 Clinically not improved, 1.
 High acid curve, persistent, 21 (62 per cent.).
 Clinically improved, 13 (62 per cent.).
 Clinically not improved, 8 (38 per cent.).

The figures in heavy type are the interesting group, namely, those in which the curve remained acid-fast, and yet the patients left the hospital free of symptoms.

EFFECTS OF RESTRICTED DIET AND REST IN BED UPON GASTRIC HYPERSECRETION. The fractional test-meal is an ideal medium for the demonstration of hypersecretion. As the successive samples are removed from the stomach at quarter-hour intervals the proportion of food or cereal to the digestive fluid becomes smaller. With normal motility the last portion of the gruel disappears at two hours. It is at this time that hypersecretion when present becomes evident, for from this point one removes every fifteen minutes a sample of secretory fluid unadulterated by food. This is the pure secretion of gastric tubules; it is usually profuse so that large amounts can be removed, and it continues sometimes for several periods or even hours after the food has passed the pylorus. In exaggerated instances as much as 30 c.c. of pure acid fluid can be removed every five minutes.

The exact clinical significance of alimentary hypersecretion (we shall omit from present discussion continuous hypersecretion) has yet to be determined. Strauss,⁷ Zweig⁸ and others who noted the phenomenon described it as a pathological factor and ascribed its presence to the existence of an organic lesion of some part of the alimentary tract. Gastric or duodenal ulcer, chronic appendicitis or reflex irritation of gall-stones were and are all held responsible for the stimulation of this excessive fluid. But opinion is not uniform on the significance of its presence, and we need only quote Rehfuss,⁹ who in a recent article spoke of hypersecretion as being of no pathological importance and of its presence in several normal controls.

The period in the cycle of digestion in which hypersecretion is most evident is the period following the evacuation of the food. The titer of this hypersecretory fluid is usually high in acid, averaging from 60 to 80 per cent.; practically all of it is free acid; only a very small percentage is present as combined acid and practically none as acid salts. It is at this period that the pains of ulcer are often most marked; this remains true whether we ascribe the pains

⁷ *Deutsch. Arch. klin. Med.*, 1895, lvi, 120.

⁸ *Arch. Verdauungs.*, 1907, xiii, 143.

⁹ *Jour. Am. Med. Assn.*, 1918, lxxi, 1535.

to the direct action of the excess of free acid upon the ulcer or the stomach wall or whether we attribute the pains to the exaggerated peristaltic waves or hunger contractions which become evident during this part of the digestive cycle.

Whatever the significance, hypersecretion is a common phenomenon in gastric and duodenal ulcer; it was present twenty times in this series of 34 cases, appearing toward the end of the period of food digestion as a postdigestive or alimentary hypersecretion.

We are interested in knowing what effect, if any, medical treatment, consisting of a marked restriction in food and rest in bed, has upon this factor. A close association is noted between hypersecretion and hyperacidity; 16 of the 20 instances of hypersecretion were in cases with gastric hyperacidity. In 9 of the 20 cases, where

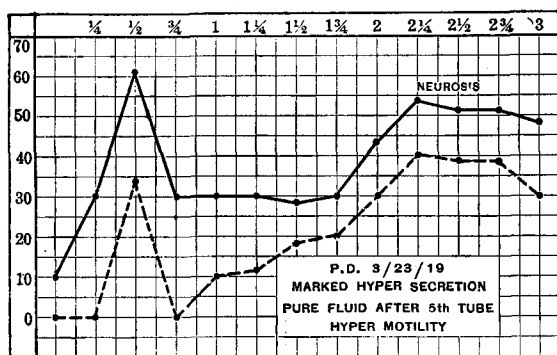


CHART XXI

present, hypersecretion was markedly improved or caused to disappear by medical treatment, a percentage of 45 per cent. In the other 11 cases, or 55 per cent., no effect was noted. The beneficial results of treatment were often very marked in this respect. Thus, for instance, Chart XXI is the curve of a case of gastric neurosis with hypersecretion, this curve being taken upon admission to the hospital, service of Dr. E. Libman. Chart XXII is the same case after six days of modified Sippy diet. Note that the character of the curve has changed; the acidity is somewhat higher but the hypersecretion is less marked, and the stomach empties itself in one and three quarter hours. Chart XXIII is the curve on the twelfth day of the diet. The curve is quite normal, the observation on the chart at the end of two hours being "scant secretion;" emptying time is normal. Many well-marked examples of the effect of medical treatment in causing the disappearance of hypersecretion could be demonstrated in the cases of this series. In fact, this is one of the most striking effects of medical treatment when a good result is present.

Much disappointment was felt in that the beneficial effect was not accomplished in a greater percentage of the cases. Eleven cases, or 55 per cent., were in nowise modified by either the restricted diet, the use of antacids or the physical and psychical rest accompanying the stay in the hospital. It is hardly possible to explain the failure in this not inconsiderable percentage of the cases.

Does improvement in hypersecretion accompany a reduction in hyperacidity, or, in other words, are both factors effected in the same manner by the medical treatment? A reference to Table II is instructive.

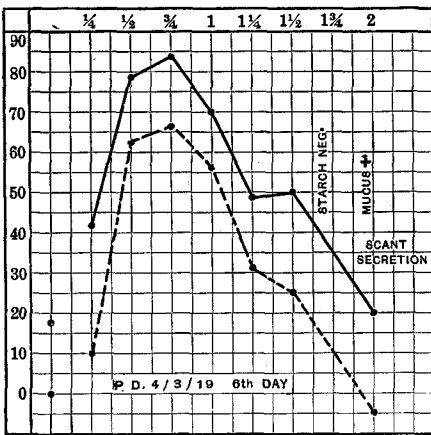


CHART XXII

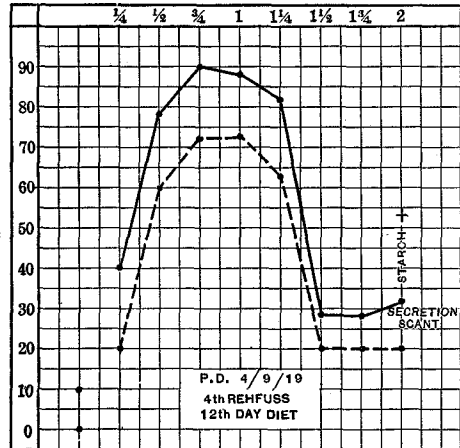


CHART XXIII

TABLE II.

Hyperacidity reduced; hypersecretion improved; clinical result: good, 6 cases; poor, 1 case.

Hyperacidity not reduced; hypersecretion not improved; clinical result: good, 8 cases; poor, 3 cases.

Hyperacidity not reduced; hypersecretion improved; clinical result: good, 2 cases. Total, 20 cases.

It is thus seen that in all but 2 cases, the last two in the table, both factors were identically influenced, either both being beneficially influenced or neither one affected for the better. The frequent coexistence of these two factors, and their similarity of behavior under treatment, suggests a close association between them.

As for the clinical results of treatment the same inconsistency is naturally seen in this group as in those in which only the effect on hyperacidity was considered. While in 11 cases, or 55 per cent., the treatment failed to affect the hypersecretion, yet 16 of the 20

cases, or 80 per cent., were discharged from the hospital clinically much improved and actually free of symptoms.

EFFECT OF MEDICAL TREATMENT ON GASTRIC MOTILITY. What is the result of our medical efforts upon delayed emptying of the stomach and persistent food residue?

Before proceeding directly to a critical review of the cases let us consider for a moment, as a preliminary, the question, "Is the fractional test-meal a good medium by which to judge the motility of the stomach?" There has been much discussion as to the relative merits of the roentgenological method for demonstrating delayed motility, and, on the other hand, of chemical methods for demonstrating postponed emptying. Both methods have undoubted value, and either method in the hands of a competent technician and observer, is beyond question, a reliable index of motility.

The fractional test-meal by allowing observations at such short intervals as a quarter of an hour seems to have the advantage over both other methods, these latter being limited to a single observation at the termination of a stated interval. With the fractional method one can state within a few minutes just when the last remnant of food has passed the pylorus. In every instance in which a six-hour residue was reported by roentgen-ray methods a chemical delayed motility was also evident with the Rehfuß method. On the other hand innumerable instances are met with in which slighter grades of delayed emptying are evident by this chemical method, which evade entirely the roentgenologist.

Using 500 c.c. of thick oatmeal gruel as a test breakfast, normal motility with the fractional method may be regarded as one and three quarters to two hours; in cases with moderate degrees of atony up to two and a quarter hours.

In this series of 34 cases of ulcer, or ulcer suspects, there were 13 instances of delayed motility, using the fraction test as a criterion. The time of emptying varied from two and a quarter hours to a maximum time of three and a half to four hours. It is in this field that the optimum effect of medical treatment was obvious.

The following two charts illustrate the improvement in motility which resulted in a case in which the diagnosis of penetrating ulcer of the lesser curvature was radiographically demonstrated. Chart XXIV is the curve taken upon admission to the hospital (service of Dr. E. Libman). Note that after three hours the iodine test for starch (oatmeal gruel) was still ++. After twenty-six days of treatment (Chart XXV) shows emptying time reduced to one and a half hours. This result is striking.

Or, another case, one of probable gastric ulcer; symptoms one and a half years in duration; periodic remitting attacks of heartburn and eructations and loss of weight. Chart XXVI is the curve on admission (service of Dr. E. Libman). The note on the chart reads "three and a quarter hours p. c., starch ++." Chart XXVII is the

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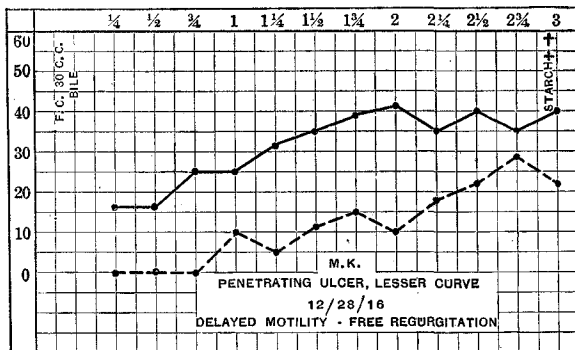


CHART XXIV

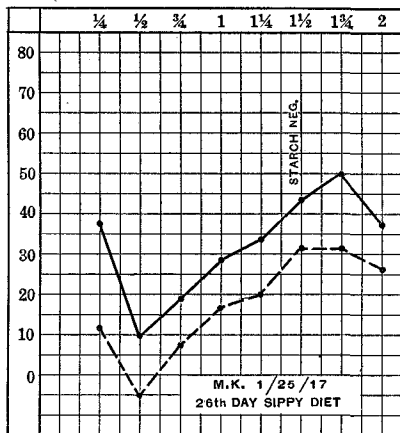


CHART XXV

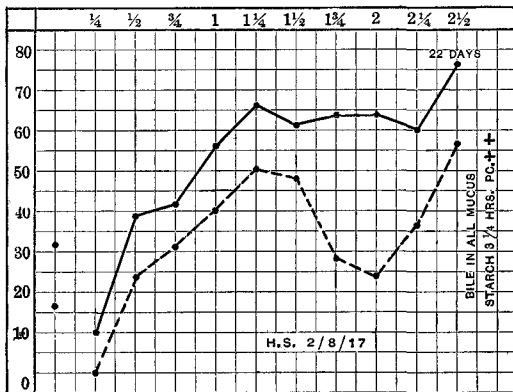


CHART XXVI

curve of the same case after six days of strict dieting; after two and a quarter hours the stomach has already evacuated the last traces of starch.

The preceding 2 cases are undoubtedly examples of delayed motility due to pylorospasm, for it is hardly conceivable that a real organic stenosis would have resolved in so short a period as six days, as obtained in the second of these 2 cases.

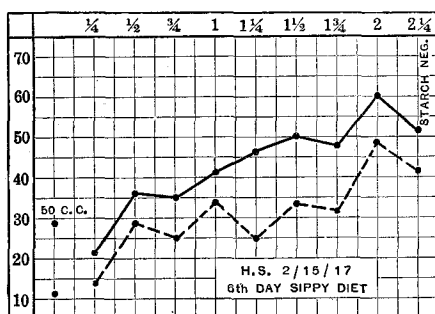


CHART XXVII

The following charts demonstrate the results of medical treatment in a case of organic stenosis due to pyloric ulcer. The patient, a man, aged fifty-four years, had been under my observation for about

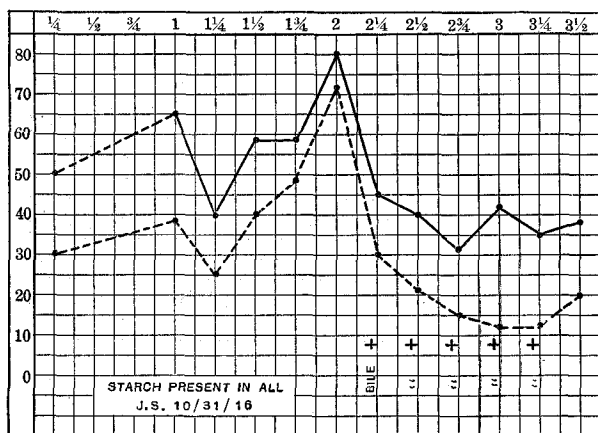


CHART XXVIII

two years. He had residual vomiting, periodic pain and loss of weight; his Ewald test breakfast showed high acidity, sarcinae, yeast and marked food stasis. Repeated radiographic examinations failed to show a defect or suspicion of carcinoma, though confirming the delay in evacuation. Chart XXVIII is the acid curve upon

admission (service of Dr. E. Libman). At the end of three and a half hours starch was still present in all the specimens withdrawn. Chart XXIX is the curve on the ninth day of treatment. After three hours starch is still present in all tubes. Chart XXX is the curve on the fifteenth day of modified Sippy diet. Starch is present as a trace after two and three quarter hours, and is absent after three hours. It is also noted that the acid curve now falls to normal when the stomach becomes empty.

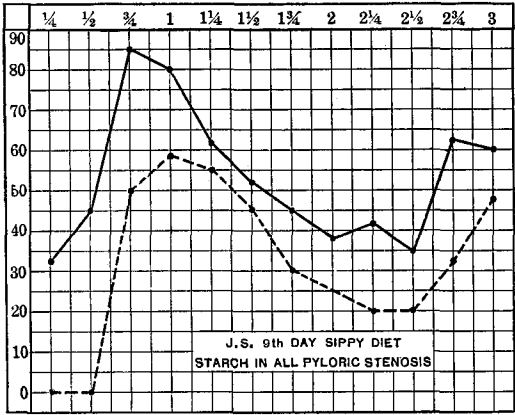


CHART XXIX

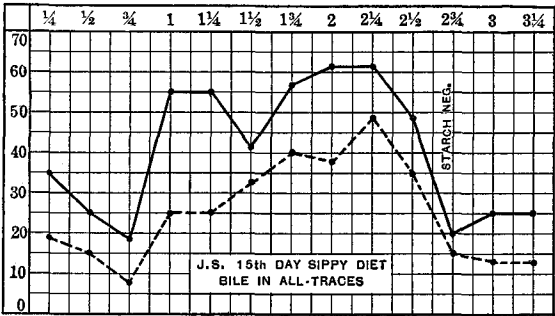


CHART XXX

In all but two of the cases of the series emptying time was definitely, in many of them markedly, shortened, a proportion of 85.4 per cent. Still more striking is the fact that clinical improvement as noted ran quite parallel with the reported improvement in motility. All of the 11 cases in which improved motility was accomplished were discharged free of symptoms, while the 2 cases in which the delay in motility resisted our efforts were discharged unrelieved of subjective symptoms.

A reduction of acidity did not always accompany an improvement in the motility. Thus of the 11 cases with improved emptying time, in only 3 was hyperacidity reduced, while in the remaining 5 the high acid curve persisted. In spite of the persistent acidity all of these cases were discharged free of symptoms.

Hypersecretion was noted 6 times in association with delayed emptying. In 4 of these 6 instances it was not relieved by the treatment; in these cases, though, the hypersecretion persisted, the pyloric stenosis or pylorospasm was relieved and the patient was discharged free of symptoms.

The following is a tabulation of the results of motility test which followed treatment and the day upon which the test was taken:

TABLE III.

Motility before treatment.		After treatment.	
Case 12	2 $\frac{1}{4}$ hours	1 $\frac{1}{4}$ hours	(12th day)
16	3 "	2 $\frac{1}{4}$ "	(6th day)
17	2 $\frac{3}{4}$ "	*2 $\frac{3}{4}$ "	(12th day)
21	3 $\frac{1}{4}$ "	3 "	(9th day)
		2 $\frac{3}{4}$ "	(15th day)
23	3 $\frac{1}{2}$ "	2 $\frac{3}{4}$ "	(7th day)
		1 $\frac{1}{2}$ "	(10th day)
		1 $\frac{3}{4}$ "	(12th day)
24	3 "	2 $\frac{1}{2}$ "	(3d day)
		2 $\frac{1}{2}$ "	(8th day)
27	2 $\frac{1}{2}$ "	2 $\frac{1}{4}$ "	(6th day)
28	2 $\frac{1}{2}$ "	*2 $\frac{3}{4}$ "	(3d day)
		2 $\frac{3}{4}$ "	(12th day)
30	2 $\frac{1}{2}$ "	1 $\frac{3}{4}$ "	(10th day)
34	4 "	1 $\frac{1}{2}$ "	(26th day)

* No improvement.

DISCUSSION. Having studied in detail the effect of restricted diet and rest in bed upon each of three factors which show deviation from the normal, let us try to evaluate the relative importance of the change which takes place in each of them. Let us attempt to estimate the relationship between clinical relief from symptoms (cure?) and physiological or chemical benefit.

Does medical treatment reduce the hyperacidity of ulcer, and if so, is this relief responsible for the clinical improvement?

Does restricted diet cause the disappearance of hypersecretion, and if it does, is this the factor that relieves the symptoms?

Finally, can delayed motility in the presence of ulcer be relieved by the feeding of small quantities of food often repeated? And if so, is this the factor that brings about apparent cure of symptoms? We will discuss these factors individually and collectively, recapitulating the findings in the body of the paper.

Medical treatment resulted in a net reduction of acidity in 13 out of a series of 34 cases (38 per cent.). If we wish to consider only those cases with definite hyperchlorhydria, omitting all cases with iso- or hyposecretory curves, the percentage of net lowering of acidity

is still lower (30.3 per cent.). Of these 13 cases chemically benefited 12, or 92 per cent., were discharged free of symptoms. Loose reasoning might lead one to see a relationship of cause and effect in these figures. But if we analyze those cases in which treatment failed to invoke chemical relief, and these comprise the larger proportion, we find, despite this fact, clinical relief in 13, or 62 per cent., of them. In other words, of 25 cases discharged from the hospital free of symptoms and apparently well, 13, nearly one-half, retained the same height and type of acidity as on admission. If clinical cure depended upon relief from hyperacidity then the optimum result should be in this class of cases. Almost 80 per cent. of the cases with hyperchlorhydria left the hospital clinically relieved, yet only 30.3 per cent. of these showed chemical relief from the excessive acid production.

We can draw two inferences from these figures: (1) Only a small percentage of ulcer cases react to medical treatment by showing a reduction of acid produced during digestion (38 per cent.); (2) clinical improvement can take place independently of whether the hyperacidity is relieved or whether the case remains acid-fast.

As regards hypersecretion a similar conclusion is soon arrived at. Twenty cases in the series showed hypersecretion; in 9 cases, or 45 per cent., medical treatment caused the disappearance of this abnormal factor, in the other 11, or 55 per cent. of the cases, medical treatment failed to alter the hypersecretion. Yet 80 per cent. of these cases left the hospital apparently well. Exactly 50 per cent. of the clinically cured cases still retained hypersecretion upon discharge from the hospital, and yet subjectively the pyrosis, heartburn and pain had disappeared.

From these figures we can again draw two conclusions: (1) Medical treatment, consisting of restricted diet and rest in bed, causes the cessation of hypersecretion in 45 per cent. of the cases, a fair proportion; (2) clinical improvement takes place as often in cases with persistent hypersecretion as in those relieved of their excessive flow of gastric juice, and is apparently not dependent upon it.

Finally, we shall discuss the relationship between improved gastric motility and clinical relief. There were 13 cases of delayed motility; in 11, or 85.4 per cent., medical treatment succeeded in alleviating this symptom and reducing the emptying time to normal. All of these 11 cases were in addition freed of subjective complaints. Two cases resisted treatment (motility unimproved), and they were discharged clinically unrelieved.

There are no instances of clinical cure that could be solely attributed to reduced acid secretion when delayed motility was present as a complicating factor. Unless relief is had from the pylorospasm we fail to note the disappearance of subjective symptoms. By stating that relief of pylorospasm results in clinical cure and is probably the cause for amelioration of symptoms we have only answered

part of the question. Most of the cases in this series were not complicated by delayed motility; they were cases with hyperacidity and hypersecretion but normal motility. We have tended throughout this study to discredit the idea that clinical relief is built upon a reduction of the hyperacidity or hypersecretion and can and does take place independent of chemical change.

Then to what change in the physiology or pathology of the stomach can one attribute the relief from symptoms in cases not complicated by pylorospasm? No data in this study throws any light on this question. The answer must be sought and will probably be found in the radiographic studies of Ginsberg, Tumpausky and Hamburger,¹⁰ Carlson,¹¹ Hardt¹² and others.

These authors have demonstrated the close relationship between subjective pain and exaggerated peristalsis or hunger contractions. It is quite likely that restricted diet and bed rest have a quieting influence upon gastric contractions, diminishing the amplitude and violence of these contractions. Reduction of acidity and secretion may or may not accompany the reduced tonus of the stomach.

The present study has demonstrated that in a fair proportion of the cases medical treatment caused reduction of hyperacidity and of hypersecretion. To what can be attributed the failure to effect this change in a far larger percentage? The answer probably lies in the fact that the marked restriction of food intake is not maintained for a long enough period. Almost all schedules of "ulcer diet" increase the number and amounts of food rapidly, particularly during the second week. In fact, Lenhartz already introduces meat on the tenth day. It is a common observation that hospital patients complain bitterly of being starved in the early days of dieting, yet it is just at this period that they report the disappearance of their annoying subjective symptoms. The end of the second week, which usually marks the period of increased alimentation, is a common date for reappearance of symptoms of pain and heartburn. It has further been shown that it takes up to the sixth to the tenth day for the acid secretion to show beneficial result, as evidenced in a lowering of the curve. The earliest effect of the marked food restriction is probably diminished tonus and contractions and increased rest to the stomach walls. The later effect is a fall of acidity and secretion. The full beneficial result, particularly on the hydrochloric acid production, is probably defeated by a too early return to a more liberal diet. The introduction of meat during the second or third week is harmful; meat-free diet should be continued for weeks or even months.

It is probable, too, that a diet based in its earlier stages on milk alone, rather than on milk and eggs as in the Lenhartz diet is to be

¹⁰ Jour. Am. Med. Assn., 1916, lxxvii, 990.

¹¹ Am. Jour. Physiol., 1917, xlv, 81.

¹² Jour. Am. Med. Assn., 1918, lxx, 837.

preferred. The amount of secretion called forth in the digestion of a milk-egg diet is far greater and the emptying time is much longer for a milk-egg mixture than for a milk meal, or certainly for a cereal meal. Personally, I would favor rather a greater liberality and earlier introduction of cereals and more restraint in the use of eggs.

It has been demonstrated in a previous paper by the author¹³ that antacids should be used often and in small doses, lest they in themselves increase or stimulate the acid cells to production. Nor can the influence of the psychical factor be overlooked. Mental contentment during a course of treatment is essential. A noisy hospital ward; the bad example of a bed-neighbor who is a neurotic and constantly complaining of the food, the treatment and his symptoms; mental disturbance over economic conditions at home, are all influences that tend to cause persistence of secretory and motor abnormalities and deprive the patient of the full benefit of his rest in bed and dietary cure. This principle applies as well to the ulcer cases as it more evidently does to the cases of functional secretory disturbances or neurosis. A patient who is unhappy during his treatment is unlikely to get well.

One cannot overlook the physical difficulties of treating many cases by "ulcer diet" in a busy hospital ward. The war intensified these difficulties many times by creating a shortage of nurses. It is not an easy matter for a limited number of ward nurses to serve milk every hour, give antacid medication on the alternating half-hours and look after the general wants of the patients in addition. Cereal which has been delayed in transit and becomes cold is tasteless and to many patients disagreeable to eat. I fear that many of the failures to obtain better results are due to the physical inability of even the best hospital staff to live up to the details and the schedule of these time and attention-consuming dietary regimens.

Segregation of cases and special nursing facilities would solve many of these difficulties. This probably explains why the results in private practice are far better and more permanent than those in the hospital public service.

Cases that fail to show clinical and chemical improvement are of two kinds: those with advanced indurated ulcers which are resistant to treatment and those with marked neurosis. The first class can be reduced in number by more persistent and more protracted treatment. The second group requires the expert care of a neurologist, often of a psychanalyst. Mistakes in diagnosis undoubtedly form a third group of not inconsiderable proportion. The beneficial effects of medical treatment are seen in those cases of hyperacidity, hypersecretion and pylorospasm accompanying latent cholelithiasis or chronic appendicitis, as well as in ulcer cases or functional

¹ Crohn: Jour. Am. Med. Assn., 1918, clv, 801.

secretory disturbances. This remark applies to immediate results rather than to permanent benefits.

It is to be regretted that the cases in this series could not be observed for a sufficiently long period to determine the durability of the result and to determine whether a relation existed between improved physiological function and permanent cure or relief.

There is a large field for research still open along these lines. Much remains to be learned regarding the physiology and pathology of the stomach during and after medical treatment. It is only by close study and observation that we will learn to account for our failures and learn to recognize the factors that contribute to the clinical cure of these patients.

CLINICAL EXPERIENCE WITH SAHLI'S SPHYGMOBOLOMETER.¹

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WHEN this study was first begun nearly ten years ago it was with the purpose of applying a method of studying the circulatory efficiency of chronic diseases in measurable units, and so, of estimating the effect of drugs, of exercise, of rest, of food and of other extramedicinal measures, in order to prescribe any or all of them sufficiently accurately to promote the most rapid recovery, to continue the greatest efficiency and to avoid overloading the circulation.

Up to then no functional tests of the efficiency of the circulation, even as satisfactory as the modern functional tests of renal elimination, had been devised, especially for chronic invalids with damaged hearts, vessels and kidneys. The method of *Sphygmobolometry*, which the Swiss clinician founded upon the dynamics rather than upon the statics of the circulation, certainly promised much; and the later simplified and more accurate method of *Volume bolometry*, even more.

I purposely limited my two previous papers² of this series,

¹ From Memorial Laboratory and Clinic, Cottage Hospital, Santa Barbara, California.

² Potter, N. B.: Sahl's Pocket Sphygmobolometer; Demonstrated at a meeting of the Medical Section of the New York Academy of Medicine, November 19, 1912. Potter, N. B.: Sahl's Volume Sphygmobolometer; A Recent Improvement over the older Pressure Sphygmobolometer; AM. JOUR. MED. SC., October, 1918, No. 4, clvi.